A12

THREE-DIMENSIONAL SHAPE MEASURING DEVICE

Publication number: JP2002122417 (A)

Publication date: 2002-04-26

Inventor(s): AOKI HIROMICHI; NAKAJIMA MASATO; TAKEMURA YASUHIRO; MIMURA KAZUHIRO

Applicant(s): SUMITOMO OSAKA CEMENT CO LTD

Classification:

- international: ***G01B11/24; G01B11/245; G01B11/25; G06T1/00;*** **G01B11/24; G06T1/00;** (IPC1-7): G01B11/24; G01B11/25; G06T1/00

- European:

Application number: JP20000315211 20001016

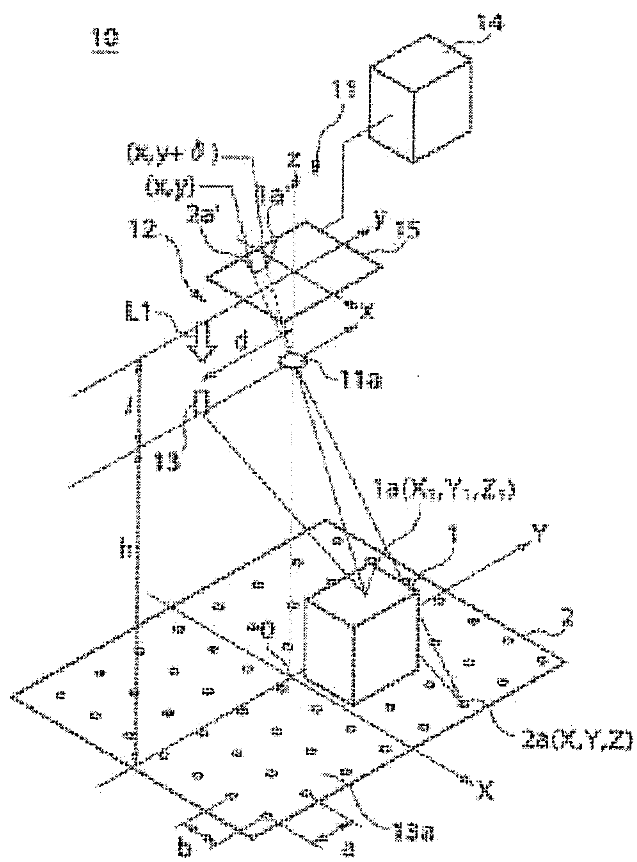
Priority number(s): JP20000315211 20001016

Also published as:

JP3689720 (B2)

Abstract of **JP 2002122417 (A)**

PROBLEM TO BE SOLVED: To provide a three-dimensional shape measuring device having a wide height measuring range of a monitoring object and using bright points. SOLUTION: This three-dimensional shape measuring device is equipped with a projection means 12 for projecting plural bright points 13a arranged in a grid shape at fixed intervals a in a first direction (y' axis direction) and at fixed intervals b larger than the intervals a in a second direction (x' axis direction) orthogonal with the first direction on an imaging region 2 where an imaging object 1 is placed, an imaging means 11 installed in the prescribed direction (y axis direction) viewed from the projection means 12, for imaging the plural bright points 13a projected on the imaging region 2 where the imaging object 1 is placed,; and a shape operation means 14 for operating the three-dimensional shape of the imaging object 1 by comparing bright point images 1a' imaged by the imaging means 11 with a reference image 2a'. The device is constituted so that, assuming n as a natural number and the diameter of the bright point as c, the angle &theta formed between the prescribed direction (y axis direction) and the first direction (y' axis direction) is nearly equal to arctan (b/(a.n)) and larger than arcsin (c/a).



Data supplied from the ***esp@cenet*** database — Worldwide

(19)日本国特許庁(JP)　(12)特　許　公　報(B2)　(11)特許番号
特許第3689720号
(P3689720)

(45)発行日　平成17年8月31日(2005.8.31)　(24)登録日　平成17年6月24日(2005.6.24)

(51)Int.Cl.[7]　FI
G01B 11/25　G01B 11/24 E
G06T 1/00　G06T 1/00 315

請求項の数 3　(全 10 頁)

(21)出願番号　特願2000-315211 (P2000-315211)
(22)出願日　平成12年10月16日 (2000.10.16)
(65)公開番号　特開2002-122417 (P2002-122417A)
(43)公開日　平成14年4月26日 (2002.4.26)
審査請求日　平成15年6月17日 (2003.6.17)

(73)特許権者　000183266
住友大阪セメント株式会社
東京都千代田区六番町６番地２８
(74)代理人　100097320
弁理士　宮川　貞二
(74)代理人　100096611
弁理士　宮川　清
(74)代理人　100098040
弁理士　松村　博之
(73)特許権者　899000079
学校法人慶應義塾
東京都港区三田２丁目１５番４５号
(74)代理人　100097320
弁理士　宮川　貞二

最終頁に続く

(54)【発明の名称】三次元形状測定装置

(57)【特許請求の範囲】

【請求項１】

撮像対象物を置く撮像領域に、第１の方向に一定の間隔ａ、前記第１の方向に直角な第２の方向に前記間隔ａよりも大なる一定の間隔ｂで格子状に配列された複数の輝点を投影する投影手段と；

前記投影手段から見て所定の方向に設置された、前記撮像対象物の置かれた撮像領域に投影された複数の輝点を撮像する撮像手段と；

前記撮像手段で撮像された輝点画像と、基準画像とを比較して、前記撮像対象物の三次元形状を演算する形状演算手段とを備え；

前記所定の方向と前記第１の方向とのなす角度は、ｎを自然数とするとき、ａｒｃｔａｎ（ｂ／（ａ・ｎ））にほぼ等しく、且つ輝点の直径をｃとするとき、前記角度はａｒｃｓｉｎ（ｃ／ａ）より大であることを特徴とする；

三次元形状測定装置。

【請求項２】

前記投影手段が、コヒーレント光を発生する光源と；

前記光源で発生されたコヒーレント光を通過させる２枚の回折格子とを備え；

前記２枚の回折格子は、それぞれの回折方向がほぼ直交するように配置されている；

請求項１に記載の三次元形状測定装置。

【請求項３】

前記回折格子は、ファイバーグレーティングである、請求項２に記載の三次元形状測定装

置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、三次元形状測定装置に関し、特に対象領域内の物体や人物の高さや姿勢の変化を監視するための三次元形状測定装置に関するものである。

【０００２】

【従来の技術】

病院の病室内あるいはトイレ内の患者等のプライバシーを損なわずに、異常を知るための監視装置として、従来から、監視対象領域に格子状に配列された輝点を投影してその画像を撮影し、撮影された画像中の輝点の基準位置からの位置変化によって対象領域の高さ変化を検出し、対象領域内の物体や人物の有無や高さ変化、姿勢変化を監視する装置が提案されている。

【０００３】

【発明が解決しようとする課題】

このような従来の装置では、監視対象領域内に物体などが存在しない状態における輝点の位置からの、物体が存在するときの輝点の移動量を調べて物体の高さを計算する。しかしながら、その高さは、物体が存在するときの輝点が、物体が存在しないときの隣の輝点の位置まで移動してしまうところで輝点同士の区別が困難となり、それ以上の測定ができなかった。図７（ａ）に監視対象領域に物体が存在しない場合の輝点画像の様子を、また図７（ｂ）に物体の存在により、ある場所の輝点が隣の輝点まで移動してしまう様子を示す。図７（ｂ）では、輝点１１１ｃ、１１１ｄが移動して隣の輝点１１１ａ、１１１ｂの図７（ａ）での位置まで移動してしまっており、これ以上の輝点の移動を生じさせる高さの物体は測定できない。例えば、図７（ｂ）での１１１ｃ、１１１ｄが更に左に移動してしまうと、その輝点が１１１ａ、１１１ｂと区別できなくなってしまう。

【０００４】

そこで本発明は、監視対象物の高さ測定範囲が広い、輝点を用いた三次元形状測定装置を提供することを目的とする。

【０００５】

【課題を解決するための手段】

上記目的を達成するために、請求項１に係る発明による三次元形状測定装置１０は、例えば図１に示すように、撮像対象物１を置く撮像領域２に、第１の方向（ｙ’軸方向（図２））に一定の間隔ａ、第１の方向（ｙ’軸方向）に直角な第２の方向（ｘ’軸方向）に間隔ａよりも大なる一定の間隔ｂで格子状に配列された複数の輝点１３ａを投影する投影手段１２と；投影手段１２から見て所定の方向（ｙ軸方向）に設置された、撮像対象物１の置かれた撮像領域２に投影された複数の輝点１３ａを撮像する撮像手段１１と；撮像手段１１で撮像された輝点画像１ａ’と、基準画像２ａ’とを比較して、撮像対象物１の三次元形状を演算する形状演算手段１４とを備え；所定の方向（ｙ軸方向）と前記第１の方向（ｙ’軸方向）とのなす角度θは、ｎを自然数とするとき、ａｒｃｔａｎ（ｂ／（ａ・ｎ））にほぼ等しく、且つ輝点の直径をｃとするとき、前記角度はａｒｃｓｉｎ（ｃ／ａ）より大であるように構成されている。

【０００６】

基準画像は、典型的には、撮像対象物が置かれていない撮像領域に投影された輝点を撮像した画像である。ここで輝点画像と基準画像、はイメージ画像に限らず、輝点の位置を特定する座標によるものであってもよい。

【０００７】

このように構成すると、第１の方向（ｙ’軸方向（図２））に一定の間隔ａ、第１の方向に直角な第２の方向に間隔ａよりも大なる一定の間隔ｂで格子状に配列された複数の輝点を投影する投影手段と、投影手段から見て所定の方向に設置された、撮像対象物１の置かれた撮像領域２に投影された複数の輝点を撮像する撮像手段とを備える。また所定の方向

と第１の方向とのなす角度は、ｎを自然数とするとき、ａｒｃｔａｎ（ｂ／（ａ・ｎ））にほぼ等しく、且つ輝点の直径をｃとするとき、前記角度はａｒｃｓｉｎ（ｃ／ａ）より大であるように構成されているので、撮像対象物の測定範囲をさらに拡大することができる。

【０００８】

さらに請求項２に記載のように、また例えば図２に示すように、請求項１に記載の三次元形状測定装置１０では、投影手段１２が、コヒーレント光Ｌ１を発生する光源Ｌと；光源Ｌで発生されたコヒーレント光Ｌ１を通過させる２枚の回折格子１３とを備え；２枚の回折格子１３は、それぞれの回折方向がほぼ直交するように配置されている。

【０００９】

また請求項３に記載のように、回折格子１３は、ファイバーグレーティングとするとよい。回折格子を通過したコヒーレント光は干渉によりパターンを生成する。回折格子は、ファイバーグレーティングの他、例えば複数のスリットを平行に切ったスリット板、シリンドリカルレンズアレイであってもよい。また２枚のシリンドリカルレンズアレイの代わりに、マイクロレンズアレイを用いてもよい。

【００１０】

【発明の実施の形態】

以下、本発明の実施の形態について、図面を参照して説明する。なお、各図において互いに同一あるいは相当する部材には同一符号または類似符号を付し、重複した説明は省略する。

【００１１】

図１は、本発明の実施の形態である三次元形状測定装置１０の全体像を示す概念的斜視図である。図中測定対象物ないしは撮像対象物としての直方体形状をした物体１が、測定対象領域ないしは撮像対象領域としての平面２上に載置されている。ＸＹ軸を平面２内に置くように、直交座標系ＸＹＺがとられており、物体１はＸＹ座標系の第１象限に置かれている。物体の代わりに人物を撮像対象物としてもよい。

【００１２】

一方、図中Ｚ軸上で平面２の上方には撮像手段としての撮像光学系１１が配置されている。ここでは便宜上撮像光学系は撮像レンズとしての１つの凸レンズ１１ａで構成されているものとして図示してある。撮像光学系１１の撮像レンズ１１ａは、その光軸がＺ軸に一致するように配置されている。撮像レンズ１１ａが、平面２あるいは物体１の像を結像する結像面（イメージプレーン）１５は、Ｚ軸に直交する面である。結像面１５内にｘｙ直交座標系をとり、Ｚ軸が、ｘｙ座標系の原点を通るようにする。

【００１３】

平面２から撮像レンズ１１ａと等距離で、撮像レンズ１１ａからＹ軸の負の方向に距離ｄだけ離れたところに、ファイバーグレーティング（ＦＧ）素子１３が配置されている。ＦＧ素子１３を含んで、投影手段としての輝点投影光学系１２が構成されている。ここで結像面１５の中心とＦＧ素子の中心とを結ぶ線を基線と呼ぶ。基線はｙ軸方向に向いており、ｄは基線方向の距離（基線長）である。図２を参照して後で説明するように、ＦＧ素子１３には光源Ｌの発生するレーザー光Ｌ１がＺ軸方向に入射して、格子状に点が配列されたパターン１３ａが平面２に照射される。即ち、物体１と平面２は、パターン状照明光で照明される。撮像光学系１１には、画像処理手段としてのコンピュータ１４が電気的に接続されている。形状演算手段はコンピュータ１４内に内臓されている。即ち、ハードディスクやＲＡＭ等の記憶部にインストールされた例えば演算プログラムである。

【００１４】

さらに図１を参照して、三次元形状測定の原理を説明する。後で詳しく説明するＦＧ素子１３により平面２に投影された輝点パターン１３ａは、物体１が存在する部分は、物体１に遮られ平面２には到達しない。ここで物体１が存在しなければ、平面２上の点２ａ（Ｘ，Ｙ，Ｚ）に投射されるべき輝点は、物体１上の点１ａ（Ｘ１，Ｙ１，Ｚ１）に投射される。輝点が点２ａから点１ａに移動したことにより、また撮像レンズ１１ａとＦＧ素子１

３とが距離ｄだけ離れているところから、結像面１５上では、点２ａ’（ｘ，ｙ）に結像すべきところが点１ａ’（ｘ，ｙ＋δ）に結像する。即ち、ｙ軸方向に距離δだけ移動する。実際は、点１ａ’は、ｙ軸上の点でなければｘ軸方向にもδｘだけ移動するが、ここではその表示は省略してある。

【００１５】

このδを計測することにより、物体１上の点１ａの位置が三次元的に特定できる。このように、ある輝点が、物体１が存在しなければ、結像面１５上に結像すべき点と、結像面１５上の実際の結像位置との差を測定することにより、物体１の三次元形状が計測できる。あるいは物体１の三次元座標が計測できるといってもよい。輝点の対応関係が不明にならない程度に、パターン１３ａのピッチ、即ち輝点のピッチを細かくすれば、物体１の三次元形状はそれだけ詳細に計測できることになる。

【００１６】

ＦＧ素子１３の中心と撮像レンズ１１ａの中心とは、平面２に平行に距離ｄだけ離して配置されており、撮像レンズ１１ａから結像面１５までの距離はｌ（エル）（撮像レンズとしての凸レンズ１１ａの焦点とほぼ等しい）、撮像レンズ１１ａから平面２までの距離はｈ、撮像対象物１の点１ａの平面２からの高さはＺ（図１ではＺ１と図示）である。撮像対象物１が平面２上に置かれた結果、結像面１５上の点２ａ’はδだけ離れた点１ａ’に移動した。

このような関係において、Ｚは次の式１のようにδを含む式で表される。この式を用いれば、トイレ内の人物などの姿勢を三次元的に知ることができる。

$Z = (h^2 \cdot \delta) / (d \cdot l + h \cdot \delta)$　…式１

【００１７】

図２を参照して、ＦＧ素子１３を説明する。ＦＧ素子１３は、直径が数十ミクロン、長さ１０ｍｍ程度の光ファイバを１００本程度シート状に並べて、それを２枚ファイバーが直交するように重ね合わせたものである。ＦＧ素子は、シートが平面２に平行に（Ｚ軸に直角に）配置される。このＦＧ素子１３に、レーザー光源Ｌが発生したレーザー光Ｌ１を、Ｚ軸方向に入射させる。するとレーザー光Ｌ１は、個々の光ファイバーの焦点で集光したのち、球面波となって広がって行き、干渉して、測定領域ないしは撮像領域としての投影面である平面２に、正方格子状に輝点マトリクスである輝点パターン１３ａが投影される。言いかえれば、平面２またはその上の物体１は、輝点パターン１３ａが投影されることによって、いわば輝点パターン状照明光で照明される。

【００１８】

このようなＦＧ素子１３によれば、光の回折効果により、グレーティングからの距離に依らずに点状光（輝点）のコントラストの良いシャープな照明パターンを得ることができ、パターンの撮像に好適である。またこのようなＦＧ素子を用いるときは、輝点の移動量を測定して演算するだけで三次元形状が測定できるので、三次元形状の測定が比較的簡単な演算手段で実現できる。また、光量を集中できるので周囲が明るい状態でも照明パターン（ここでは輝点）の撮像が簡単にでき好適である。

【００１９】

ＦＧ素子１３の光ファイバは、基線方向（図中ｙ軸方向）を向いているとは限らず、ｘｙ平面に平行に、ＦＧ素子１３の中心を通るＺ軸方向に平行な軸を回転軸とし、θだけ回転させてある。図中、直交する光ファイバに平行な座標をｘ’ｙ’座標とすれば、ｙ’軸はｙ軸に対し、ｘ’軸はｘ軸に対し角度θだけ傾いている。即ち、一つの格子方向と基線との成す角がθである。

【００２０】

ここで平面２上の格子状輝点パターンのｙ’軸に平行な方向の間隔をａ、ｘ’軸に平行な方向の間隔をｂとする。また直交する光ファイバの直径は、両者ほぼ等しいが、ｙ’軸方向の光ファイバの直径をｘ’軸方向の光ファイバの直径よりも太くすると、輝点パターンの輝点同士の間隔は、ａ＜ｂの関係となる。なお、図１の輝点パターンは、θ＝０の場合を示している。

【００２１】
図３は、輝点間隔がａ、ｂ（ａ＜ｂ）になるようなＦＧ素子を用いた場合の輝点画像である。このような輝点画像は図２を参照して説明したようにＦＧ素子の縦と横のファイバー径即ちファイバーピッチが違うような素子を用いることによって実現できる。レーザ及びＦＧ素子による輝点の位置の計算式は、次の式２に示すような多重スリットによる干渉による干渉縞の式と同様に考えられるので、スリット間隔ｐ即ちファイバーピッチを変更すれば、干渉縞の間隔を変えることができる。ここで、y_mは周期的な鋭い極大を与えるｙ軸方向位置、ｍは自然数、λは光の波長、ｈはＦＧ素子から照明面（撮像領域の平面）までの距離、ｐはスリット間隔とする。

$y_m = m \cdot \lambda \cdot h / p$ …式２

【００２２】
輝点アレイの輝点間隔の短い（図３では間隔がａの）格子方向と基線との成す角は、θ０、θ１、θ２、・・・θｎのように置くことができる。図３では説明のためθ４まで表記し、θ５以上は図示を省略してある。このように基線の方向を設定することにより、ある輝点とその基線方向の隣接輝点の間隔を大きくすることができ、物体１の高さ測定範囲を広げることができる。輝点の大きさを無視すると隣接輝点との距離は、下式のように表される。

θ０の場合・・・・・ a

θ１の場合・・・・・ $(a^2 + b^2)^{1/2}$

θ２の場合・・・・・ $((2 \cdot a)^2 + b^2)^{1/2}$

θ３の場合・・・・・ $((3 \cdot a)^2 + b^2)^{1/2}$

θ４の場合・・・・・ $((4 \cdot a)^2 + b^2)^{1/2}$

【００２３】
このように、格子を基線に対して傾けた場合は、傾けない場合に比較して隣接輝点間距離が大きくなる。ここで、輝点が十分に小さい場合でも、実際にはθｎのｎは無限大ではなく、輝点のスポット径やゆらぎなどにより制限される。ここでθを一般式で表すと次式のようになる。θをこのような値にほぼ等しくすると、隣接輝点との距離を大きくとることができる。

$\theta = \arctan(b / (a \cdot n))$ …式３

【００２４】
このような構成にすれば、輝点アレイの縦横同時に輝点間隔を大きくして、高さ測定範囲を拡大する方法よりも、単位面積当りの輝点の個数の減少を少なくすることができ、物体の高さ測定地点を疎にすることが少なくなるので、より正確な物体の三次元測定が可能になる。また、基線長ｄは変えないので低い高さの感度を低下させることなく、高さ測定範囲を拡大することができる。

【００２５】
またａ＜ｂとすると、図４を参照して以下説明するように、輝点格子方向を基線に対して傾けて基線方向の隣接輝点間隔を拡げる場合でも、物体により輝点位置が移動するとき、隣接輝点以外の輝点にぶつかってしまうのを避けることが可能になる。

【００２６】
図４を参照して、本発明の実施の形態を説明する。図中、輝点間隔にはａ＜ｂの関係があり、間隔ａの方向と基線との角度は$\theta = \arctan(b / (3 \cdot a))$にとられている。このような基線と輝点格子の配置の場合、図中左下隅の輝点０は物体の高さに伴い、図中下から２行左から４列の位置の輝点１の方向に移動するが、この途中で図中下から１行左から２列の輝点２（または図中下から２行左から３列の輝点３）のすぐ脇に位置する可能性が発生する。輝点格子間隔を図のように、ａ、ｂと定義し、輝点の直径をｃ、ｎを自然数とすると、輝点０が輝点２に最も近い位置ある時の輝点同士の隙間ｓは、次式で表される。

$s = a \cdot b / ((a \cdot n)^2 + b^2)^{1/2} - c$ …式４

【００２７】

例えば、ａ＝ｂ＝５ｍｍ、ｃ＝１ｍｍとすると、ｓ及び輝点の大きさを差引いた輝点０－１間の距離l_{01}（エル）は、図５（ａ）の表１に示す通りとなり、ｎ＝５以上とすると、輝点同士が重なって見分けが難しくなることがわかる。これを避けるためには、式４においてｓ＞０とすればよい。即ち、次式を満たすようにすればよい。

$\theta > \arcsin(c/a)$ …式５

【００２８】

またここで、ｂ＝８ｍｍ（＞ａ＝５ｍｍ）に変更すると、（ｂ）の表２に示すように、ノイズなどの影響がなければ、ｎ＝７の角度まで浅くすることができる。このときは、l_{01}の値も大きくなっており、高さ測定範囲が拡大していることがわかる。このように、縦横で違う輝点間隔の輝点画像を用いることにより、基線方向の隣接輝点を伸ばすことができ、高さ測定範囲を拡大することが可能になる。

【００２９】

以上、図３で説明したように、θ１、θ２、θ３・・・・と角度を浅くしていくと（但し０度ではない）、基線方向の隣接輝点間隔が拡がり、高さ測定範囲を拡大することができるが、実際には輝点の大きさなどの影響でこの角度はあまり浅くできない。そこで、図４で説明したような輝点の配置にすることによって、角度を浅くすることができるのである。

【００３０】

ここまでで説明した実施の形態では、縦と横でファイバー径の違うＦＧ（ファイバーグレーティング）素子を用いて、格子間隔の違う輝点アレイを実現したが、他の手段として一般的な透過型一次元回折格子を２枚、格子が直交するように重ねあわせることによっても実現可能である。この場合回折格子のピッチの違うものを使用して輝点の格子間隔を縦横で違うようにする。回折格子やＦＧ素子を用いて作った輝点は、呆けが少なく、また素子と物体との距離の影響を受けにくいので好適である。またＦＧ素子の場合、遮光される場所がなくＦＧ素子に入射した光のほとんどを輝点の生成に利用することができるので、エネルギー効率的が高く、好適である。

【００３１】

更に図６（ａ）の平面図とＡ－Ａ断面図で示したマイクロレンズアレイ模式構成図に示すように、小さなレンズが縦横に隙間無く敷詰められたマイクロレンズアレイ（ＭＬＡ）を用いても実現できる。この場合も、縦横でレンズピッチの違う素子を用いて輝点の格子間隔を縦横で違うようにすることができる。このようなＭＬＡは、材料として合成樹脂を用いて、金型によるプレス加工で簡単に製作することができるので好適である。また図示のような、各レンズ間に隙間のないＭＬＡを使用すれば、入射してきた光束のほとんどを輝点の生成に利用することができ、エネルギー効率が高く好適である。

【００３２】

更に図６（ｂ）の平面図とＢ－Ｂ断面図で示したマイクロシリンドリカルレンズアレイ模式構成図に示すように、ＦＧ素子と類似の構成で、小さなシリンドリカレンズが隙間無く並んだマイクロシリンドリカルレンズアレイを２枚重ねてもよい。このとき２枚のアレイ間では、屈折力のある方向同士をほぼ直交するようにするとよい。すなわちそれぞれの回折方向がほぼ直交するように配置する。この場合も、重ねる２枚のアレイとして、互いにレンズピッチの違うものを使用して、輝点の格子間隔を縦横で違うようにする。

【００３３】

以上説明した本発明の実施の形態である三次元形状測定装置は、例えば老人介護施設のトイレなどに用いと、トイレで何か異常が生じたような場合に、プライバシーを損なうことなく、その異常を検知することができる。

【００３４】

また、光源の使用波長を可視光以外の波長としてもよい。このように構成すると、撮像対象物が人であるときなどに、対象となる人物に気づかれずに撮像することができる。

【００３５】

なお撮像素子の例としては、ＣＣＤの他にＣＭＯＳ構造の素子を使用してもよい。特にこ

れらの中には、素子自体にフレーム間差算や二値化の機能を備えたものがあり、これらの素子の使用は好適である。

【００３６】

【発明の効果】

以上説明したように、本発明によれば、第１の方向に一定の間隔ａ、第１の方向に直角な第２の方向に間隔ａよりも大なる一定の間隔ｂで格子状に配列された複数の輝点を投影する投影手段と、投影手段から見て所定の方向に設置された、撮像対象物１の置かれた撮像領域に投影された複数の輝点を撮像する撮像手段を備え、所定の方向と第１の方向とのなす角度は、ｎを自然数とするとき、ａｒｃｔａｎ（ｂ／（ａ・ｎ））にほぼ等しく、且つ輝点の直径をｃとするとき、前記角度はａｒｃｓｉｎ（ｃ／ａ）より大であるように構成されているので、撮像対象物の測定範囲を拡大した三次元形状測定装置を提供することが可能となる。

【図面の簡単な説明】

【図１】本発明の実施の形態である三次元形状測定装置の概念的斜視図である。

【図２】図１の実施の形態で用いるＦＧ素子を説明する概念的斜視図である。

【図３】輝点群と基線とのなす角度を示す平面図である。

【図４】図３のθ３を抜き出して説明する平面図である。

【図５】本発明の実施例における輝点間隔と２つの輝点間の距離の表を示す図である。

【図６】本発明の実施の形態で用いることのできる回折格子のうち、マイクロレンズアレイとマイクロシリンドリカルレンズアレイを示す模式図である。

【図７】物体が無いときの輝点画像と物体により隣の輝点まで移動する輝点のある画像を示す平面図である。

【符号の説明】

１　撮像対象物

２　撮像領域

１０　三次元形状測定装置

１１　撮像光学系

１１ａ　撮像レンズ

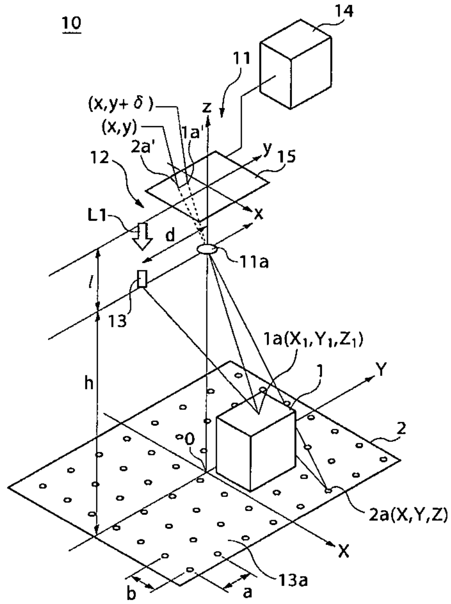
１２　投影光学系

１３　ＦＧ素子

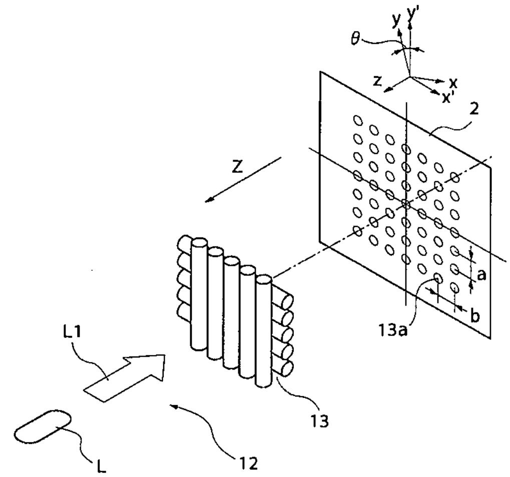
１５　結像面

１４　画像処理装置

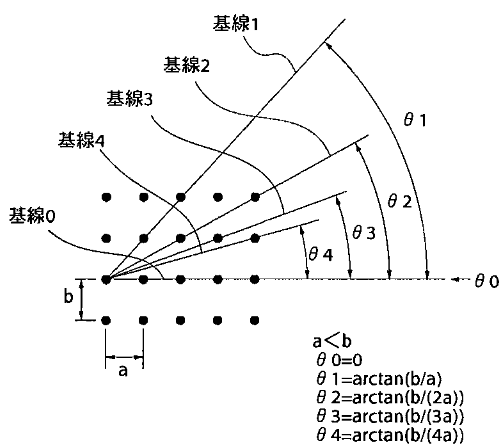
【図１】



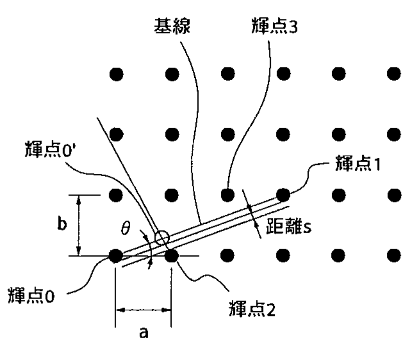
【図２】



【図３】



【図４】



【図５】

（ａ）

表１　輝点間隔ｓと輝点１−０間の距離 l_{01}

（ａ＝ｂ＝５ｍｍ、ｃ＝１ｍｍ）

n	s(mm)	l_{01}(mm)
1	2.54	6.07
2	1.24	10.2
3	0.58	14.8
4	0.21	19.6
5	-0.019	24.5

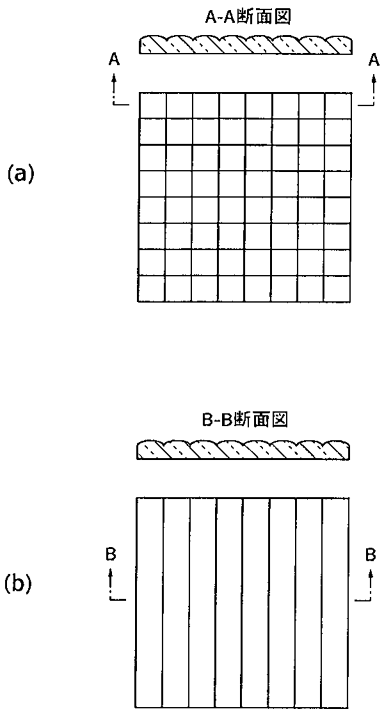
（ｂ）

表２　輝点間隔ｓと輝点１−０間の距離 l_{01}

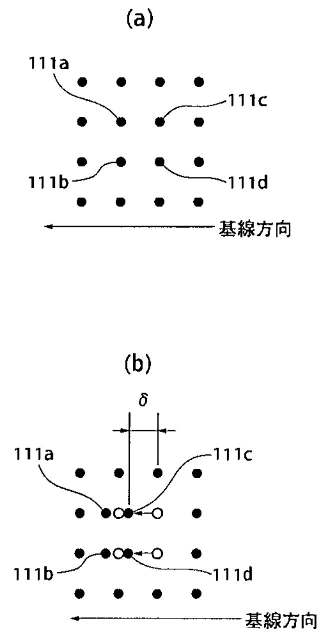
（ａ＝５ｍｍ、ｂ＝８ｍｍ、ｃ＝１ｍｍ）

n	s(mm)	l_{01}(mm)
1	3.24	8.4
2	2.12	11.8
3	1.35	16
4	0.86	20.5
5	0.52	25.2
6	0.29	30.0
7	0.11	34.9
8	-0.019	39.8

【図６】


A-A断面図
A
A
(a)
B-B断面図
B
B
(b)

【図７】


(a)
111a
111c
111b
111d
基線方向
(b)
δ
111a
111c
111b
111d
基線方向

フロントページの続き

(72)発明者　青木　広宙
神奈川県横浜市港北区日吉３－１４－１　慶応義塾大学大学院理工学研究科内
(72)発明者　中島　真人
神奈川県横浜市港北区日吉３－１４－１　慶応義塾大学理工学部内
(72)発明者　竹村　安弘
千葉県船橋市豊富町５８５　住友大阪セメント株式会社　新規技術研究所内
(72)発明者　味村　一弘
千葉県船橋市豊富町５８５　住友大阪セメント株式会社　新規技術研究所内

審査官　岡田　卓弥

(56)参考文献　特開平３－４２５０７（ＪＰ，Ａ）

(58)調査した分野(Int.Cl.^{7}，ＤＢ名)
G01B11/00-11/30
G06T 1/00

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

(57)[Claim(s)]
[Claim 1]
A projection means which projects two or more luminescent spots in which size becomes in the 2nd direction right-angled in the interval a fixed in the 1st direction, and said 1st direction from said interval a, and which were arranged in the shape of a lattice at intervals of [fixed] b on an imaging region which places an image pick-up subject;
An imaging means which picturizes two or more luminescent spots projected on an imaging region on which said image pick-up subject which saw from said projection means and was installed in the predetermined direction was put;
A luminescent spot picture picturized by said imaging means is compared with a reference image, and it has a shape calculating means which calculates three-dimensional shape of said image pick-up subject.;
When an angle of the direction of predetermined [said] and said 1st direction to make is almost equal to arctan (b/(a-n)) when making n into a natural number, and setting a diameter of a luminescent spot to c, said angle is characterized by being size from arcsin (c/a).;
A three-dimensional form measuring apparatus.
[Claim 2]
A light source in which said projection means generates coherent light;
It has a diffraction grating of two sheets which passes coherent light generated with said light source.;
Said diffraction grating of two sheets is arranged so that each diffraction direction may intersect perpendicularly mostly.;
The three-dimensional form measuring apparatus according to claim 1.
[Claim 3]
The three-dimensional form measuring apparatus according to claim 2 in which said diffraction grating is a fiber grating.

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
Especially this invention relates to the three-dimensional form measuring apparatus for supervising the object in an object domain, a person's height, and change of a posture about a three-dimensional form measuring apparatus.
[0002]
[Description of the Prior Art]
As a monitoring instrument for getting to know abnormalities, without spoiling privacies, such as a patient in the sickroom of a hospital, or a toilet, The luminescent spot arranged in the shape of a lattice is projected on a surveillance object field, the picture is photoed, the position change from the reference position of the luminescent spot in the photoed picture detects height change of an object domain from the former, and the device which supervises the object in an object domain, a person's existence, and height change and a posture change is proposed.
[0003]
[Problem(s) to be Solved by the Invention]
In such a conventional device, objective height is calculated by investigating the movement magnitude of a luminescent spot in case the object from the position of the luminescent spot in the state where an object etc. are not existed in a surveillance object field exists. However, distinction of luminescent spots became difficult in the place where a luminescent spot in case an object exists moves to the position of the luminescent spot of a next door in case an object does not exist, and measurement beyond it of the height was not completed. Signs that the luminescent spot of a certain place moves the situation of a luminescent spot picture in case an object does not exist to a surveillance object field to drawing 7 (b) to the next luminescent spot by existence of an object again are shown in drawing 7 (a). In drawing 7 (b), the luminescent spots 111c and 111d moved, it has moved to the position in drawing 7 (a) of the next luminescent spots 111a and 111b, and the object of the height which produces movement of the luminescent spot beyond this cannot be measured. If 111c and 111d in drawing 7 (b) move to the left further, it will become impossible for example, for the luminescent spot to distinguish from 111a and 111b.
[0004]
Then, this invention aims to let the height time base range of a supervisory object provide the large three-dimensional form measuring apparatus using a luminescent spot.
[0005]
[Means for Solving the Problem]
To achieve the above objects, the three-dimensional form measuring apparatus 10 by invention concerning claim 1, For example, the interval a fixed to the imaging region 2 which places the image pick-up subject 1 in the 1st direction (y' shaft orientations (drawing 2)) as shown in drawing 1. . Saw

from the projection means 12 which projects two or more luminescent spots 13a in which size becomes in the 2nd right-angled direction (x' shaft orientations) from the interval a, and which were arranged in the shape of a lattice at intervals of [fixed] b in the 1st direction (y' shaft orientations), and the; projection means 12, and were installed in the predetermined direction (y shaft orientations). Luminescent spot picture 1a' picturized by the imaging means 11 which picturizes two or more luminescent spots 13a projected on the imaging region 2 on which the image pick-up subject 1 was put, and the; imaging means 11, Compare reference image 2a', have the shape calculating means 14 which calculates three-dimensional shape of the image pick-up subject 1, and the angle theta of the direction of; predetermined (y shaft orientations), and said 1st direction (y' shaft orientations) to make. When making n into a natural number, it is almost equal to arctan (b/(a-n)), and when setting a diameter of a luminescent spot to c, said angle comprises arcsin (c/a) so that it may be size.

[0006]

A reference image is a picture which picturized typically a luminescent spot projected on an imaging region on which an image pick-up subject is not put. It may be based on coordinates which pinpoint a position of a luminescent spot picture, a reference image, and not only a ** image picture but a luminescent spot here.

[0007]

When constituted in this way, size from the interval a in the 2nd direction right-angled in the interval a fixed in the 1st direction (y' shaft orientations (drawing 2)), and the 1st direction A projection means which projects two or more becoming luminescent spots which were arranged in the shape of a lattice at intervals of [fixed] b, It has an imaging means which picturizes two or more luminescent spots projected on the imaging region 2 on which the image pick-up subject 1 which saw from a projection means and was installed in the predetermined direction was put. An angle of a predetermined direction and the 1st direction to make, When making n into a natural number, it is almost equal to arctan (b/(a-n)), and since said angle comprises arcsin (c/a) so that it may be size when setting a diameter of a luminescent spot to c, a time base range of an image pick-up subject is further expandable.

[0008]

As shown in drawing 2, still like a statement to claim 2 in the three-dimensional form measuring apparatus 10 according to claim 1. The projection means 12 is provided with the diffraction grating 13 of two sheets which passes the coherent light L1 generated with the light source L which generates the coherent light L1, and the; light source L, and the;2 sheet diffraction grating 13 is arranged so that each diffraction direction may intersect perpendicularly mostly.

[0009]

The diffraction grating 13 is good for claim 3 like a statement to consider it as a fiber grating. Coherent light which passed a diffraction grating generates a pattern by interference. A diffraction grating may be a slit plate and a cylindrical lens array which cut everything but a fiber grating, for example, two or more slits, in parallel. A microlens array may be used instead of a cylindrical lens array of two sheets.

[0010]

[Embodiment of the Invention]

Hereafter, an embodiment of the invention is described with reference to drawings. Identical codes or similar numerals are given to the member which is mutually the same or corresponds in each figure, and the duplicate explanation is omitted.

[0011]

Drawing 1 is a notional perspective view showing the overview of the three-dimensional form measuring apparatus 10 which is an embodiment of the invention. The object 1 which carried out rectangular parallelepiped shape as the measuring object in a figure or an image pick-up subject is laid on the flat surface 2 as a measuring object area or an image pick-up object domain. The

rectangular coordinate system XYZ is taken and the object 1 is put on the 1st quadrant of an XY coordinate system so that XY axis may be placed in the flat surface 2. It is good also considering a person as an image pick-up subject instead of an object.

[0012]

On the other hand, above the flat surface 2, the imaging optical system 11 as an imaging means is arranged on the Z-axis in a figure. Here, the imaging optical system is illustrated for convenience as what comprises the one convex lens 11a as an imaging lens. The imaging lens 11a of the imaging optical system 11 is arranged so that the optic axis may be in agreement with the Z-axis. The image formation face (image plain) 15 where the imaging lens 11a carries out image formation of the image of the flat surface 2 or the object 1 is a field which intersects perpendicularly with the Z-axis. xy rectangular coordinate system is taken in the image formation face 15, and the Z-axis passes along the starting point of xy coordinate system.

[0013]

At the imaging lens 11a and the equal distance, the fiber grating (FG) element 13 is arranged from the flat surface 2 at the place which only the distance d separated from the imaging lens 11a to the negative direction of the Y-axis. The luminescent spot projection optical system 12 as a projection means is constituted including FG element 13. The line which connects the center of the image formation face 15 and the center of an FG element here is called a ground line. The ground line has turned to y shaft orientations, and d is the distance (base length) of a base line direction. The laser beam L1 which the light source L generates in FG element 13 enters into Z shaft orientations, and the pattern 13a in which the point was arranged in the shape of a lattice is irradiated by the flat surface 2 so that it may explain with reference to drawing 2 later. That is, the object 1 and the flat surface 2 are illuminated by the pattern state illumination light. The computer 14 as an image processing means is electrically connected to the imaging optical system 11. The internal organs of the shape calculating means are carried out into the computer 14. That is, it is an operation program for example, it was installed in storage parts stores, such as a hard disk and RAM.

[0014]

Furthermore with reference to drawing 1, the principle of three-dimensional shape measuring is explained. The portion in which the object 1 exists is interrupted by the object 1, and the luminescent spot pattern 13a projected on the flat surface 2 by FG element 13 explained in detail later does not arrive at the flat surface 2. If the object 1 does not exist here, the luminescent spot on which it should be projected by the point 2a (X, Y, Z) on the flat surface 2 is projected by the point 1a (X1, Y1, Z1) on the object 1. the luminescent spot moved to the point 1a from the point 2a -- on the image formation face 15, the place which should be carried out image formation carries out image formation to point 2a' (x, y) at point 1a' (x, y+delta) from the place from which the imaging lens 11a and FG element 13 have separated only the distance d. That is, only the distance delta moves to y shaft orientations. In practice, if point 1a' is not a point on the y-axis, only deltax will move also to x shaft orientations, but the display is omitted here.

[0015]

By measuring this delta, the position of the point 1a on the object 1 can specify in three dimensions. Thus, if a certain luminescent spot does not exist [the object 1], when measuring the difference of the point which should be carried out image formation on the image formation face 15, and the actual image formation position on the image formation face 15, the three-dimensional shape of the object 1 is measurable. Or it is good although the three dimensional coordinates of the object 1 are measurable. If the pitch of the pattern 13a, i.e., the pitch of a luminescent spot, is made fine to such an extent that the correspondence relation of a luminescent spot does not become unknown, the three-dimensional shape of the object 1 can be measured so in detail.

[0016]

The center of FG element 13, and the center of the imaging lens 11a, Detach only the distance d in parallel with the flat surface 2, and it is arranged, and the distance to the image formation face 15

from the imaging lens 11a l (El) (almost equal to the focus of the convex lens 11a as an imaging lens), The height from the flat surface 2 of the point 1a of h and the image pick-up subject 1 of the distance from the imaging lens 11a to the flat surface 2 is Z (in drawing 1, it illustrates with Z1). an image pick-up -- a subject -- one -- a flat surface -- two -- a top -- placing -- having had -- a result -- an image formation face -- 15 -- a top -- a point -- two -- a -- ' -- delta -- only -- having separated -- a point -- one -- a -- ' -- having moved .
Z is expressed with the formula which contains delta like the following formula 1 in such a relation. If this formula is used, the posture of the person in a toilet, etc. can be known in three dimensions.
$Z = (h^2\text{anddelta}) / (d-l+h-\text{delta})$ -- Formula 1
[0017]
FG element 13 is explained with reference to drawing 2. A diameter arranges in a sheet shaped about 100 optical fibers which are tens of microns and about 10 mm in length, and FG element 13 piles it up so that a two-sheet fiber may intersect perpendicularly. An FG element is arranged in parallel [a sheet] (it is right-angled to the Z-axis) with the flat surface 2. The laser beam L1 which laser light source L generated in this FG element 13 is entered in Z shaft orientations. Then, the laser beam L1 serves as a spherical wave, after it condenses with the focus of each optical fiber, spreads, and goes and interferes, and the luminescent spot pattern 13a which is a luminescent spot matrix at the shape of a tetragonal lattice is projected on the flat surface 2 which is a surface of projection as a measurement region or an imaging region. In other words, so to speak, the flat surface 2 or the object 1 on it is illuminated by the luminescent spot pattern state illumination light by projecting the luminescent spot pattern 13a.
[0018]
According to such FG element 13, the good sharp illumination pattern of the contrast of punctiform light (luminescent spot) can be obtained according to the diffraction effect of light, without depending on the distance from a grating, and it is suitable for the image pick-up of a pattern. Since three-dimensional shape can be measured only by measuring and calculating the movement magnitude of a luminescent spot when using such an FG element, it is realizable by the calculating means in which measurement of three-dimensional shape is comparatively easy. Since light volume can be concentrated, the image pick-up of an illumination pattern (here luminescent spot) can be simply performed also in the state where the circumference is bright, and it is suitable.
[0019]
The optical fiber of FG element 13 has not always turned to the base line direction (y shaft orientations in a figure), sets the axis of rotation as an axis parallel to Z shaft orientations which pass along the center of FG element 13 in parallel with a xy plane, and has rotated only theta. If coordinates parallel to the optical fiber which intersects perpendicularly among a figure are made into x'y' coordinates, as for y' axis, only the angle theta leans to the x axis to the y-axis, as for x' axis. That is, the angle of one lattice direction and ground line to accomplish is theta.
[0020]
The interval of a direction parallel to a and x' axis is set to b for the interval of a direction parallel to y' axis of the lattice-like luminescent spot pattern on the flat surface 2 here. the diameter of the optical fiber which intersects perpendicularly -- both persons -- although it is almost equal -- the diameter of the optical fiber of y' shaft orientations -- x' -- if it is made thicker than the diameter of the optical fiber of shaft orientations, the interval of the luminescent spots of a luminescent spot pattern will serve as a relation of $a<b$. The luminescent spot pattern of drawing 1 shows the case of theta= 0.
[0021]
Drawing 3 is a luminescent spot picture at the time of using the FG element that a luminescent spot interval is set to a and b ($a<b$). Such a luminescent spot picture is realizable by using the element that it differs from each other as explained with reference to drawing 2, the diameter of a fiber, i.e., the fiber pitch, of the length of an FG element, and width. Since it is considered the equation of the

interference fringe by interference by a multiplex slit as shown in the following equation 2 the same way, the formula of the position of the luminescent spot by laser and an FG element can change the interval of an interference fringe, if slit spacing p, i.e., a fiber pitch, is changed. Here, as for y_m, h considers it as the distance from an FG element to an illuminated face (flat surface of an imaging region) by a natural number and lambda considering it as the wavelength of light, and p makes slit spacing y axial position and m which give the periodic sharp maximum.

y_m= m-lambda-h/p -- Formula 2

[0022]

the angle of the short (at drawing 3, an interval is a) lattice direction and ground line of the luminescent spot interval of a luminescent spot array to accomplish -- theta 0, theta 1, theta 2, and ... it can place like thetan. In drawing 3, it writes to theta 4 for explanation, and the graphic display is omitted more than theta5. Thus, by setting up the direction of a ground line, the interval of a certain luminescent spot and adjoining luminescent spot of the base line direction can be enlarged, and the height time base range of the object 1 can be extended. Disregard of the size of a luminescent spot will express the distance with an adjoining luminescent spot like a lower type.

In the case of theta 0 ..... a

In the case of theta 1 ..... $(a^2+b^2)^{1/2}$

In the case of theta 2 ..... (2anda) $(^2+b^2)^{1/2}$

In the case of theta 3 ..... (3anda) $(^2+b^2)^{1/2}$

In the case of theta 4 ..... (4anda) $(^2+b^2)^{1/2}$

[0023]

Thus, when a lattice is leaned to a ground line, as compared with the case where it does not lean, the distance between adjoining luminescent spots becomes large. Here, even when a luminescent spot is small enough, actually, n of thetan is restricted by the spot diameter of a luminescent spot, fluctuation, etc. rather than is infinite. If theta is expressed with a general formula here, it will become like a following formula. If theta is made almost equal to such a value, a large distance with an adjoining luminescent spot can be taken.

Theta=arctan (b/(a-n)) -- Formula 3

[0024]

Since enlarging a luminescent spot interval simultaneous in all directions [a luminescent spot array], being able to lessen reduction of the number of the luminescent spot per unit area, and making an objective height measuring spot into a non-dense rather than the method of expanding a height time base range will decrease if it has such composition, three-dimensional measurement of a more exact object is attained. The base length d can expand a height time base range, without reducing the sensitivity of low height, since it does not change.

[0025]

When leaning a luminescent spot lattice direction to a ground line, extending the adjoining luminescent spot interval of a base line direction so that it may explain below with reference to drawing 4 if a<b and a luminescent spot position moves with an object, it becomes possible to avoid whether it strikes to luminescent spots other than an adjoining luminescent spot, and that it keeps.

[0026]

An embodiment of the invention is described with reference to drawing 4. There is a relation of a<b to a luminescent spot interval among a figure, and the angle of the direction of the interval a and a ground line is taken at theta=arctan (b/(3anda)). In such arrangement of a ground line and a luminescent spot lattice, in connection with objective height, move the luminescent spot 0 of the bottom corner of the left in the figure in the direction of the luminescent spot 1 of the position of four rows from the two-line left from figure Nakashita, but. In this middle, a possibility of the luminescent spot 2 (or luminescent spot 3 of the two-line left from figure Nakashita to three rows)

of two rows of being immediately located in the side occurs from the one-line left from figure Nakashita. When a luminescent spot lattice spacing is defined as a and b as shown in a figure, the diameter of a luminescent spot is set to c and n is made into a natural number, the crevice s between the luminescent spots at the time of position **** with the luminescent spot 0 nearest to the luminescent spot 2 is expressed with a following formula.

s=a-b/(a-n) $(^{2}+b^{2})^{1/2}$-c -- Formula 4

[0027]

For example, when distance l_{01} (El) between the a=b= luminescent spots 0-1 which deducted the size of s and a luminescent spot when 5 mm and c= 1 mm becomes as it is shown in Table 1 of drawing 5 (a), and it carries out to n= 5 or more, it turns out that luminescent spots lap and distinction becomes difficult. What is necessary is to just be referred to as s> 0 in the formula 4, in order to avoid this. Namely, what is necessary is just to make it fill a following formula.

Theta>arcsin (c/a) -- Formula 5

[0028]

Here, if there is no influence of a noise etc. as shown in Table 2 of (b) when it changes into b= 8 mm (> a= 5 mm), it can be made shallow to the angle of n= 7. At this time, it turns out that the value of l_{01} is also large and the height time base range has expanded it. Thus, it is in every direction, and by using the luminescent spot picture of a different luminescent spot interval, the adjoining luminescent spot of a base line direction can be lengthened, and it becomes possible to expand a height time base range.

[0029]

in the above, drawing 3 explained -- as -- theta 1, theta 2, and theta 3 -- if .... and an angle are made shallow (however, it is not 0 times), the adjoining luminescent spot interval of a base line direction spreads, and a height time base range can be expanded, but this angle is not actually made not much shallowly under the influence of the size of a luminescent spot, etc. Then, the angle can be made shallow by using arrangement of a luminescent spot which was explained by drawing 4.

[0030]

Although the luminescent spot array from which a lattice spacing is different using FG (fiber grating) element from which the diameter of a fiber is different by length and its side was realized in the embodiment described so far, It is realizable also by piling up the general transmission type one-dimensional diffraction grating as other means so that two sheets and a lattice may intersect perpendicularly. In this case, using that from which the pitch of a diffraction grating is different, it is in every direction and the lattice spacing of a luminescent spot is made different. There is little dotage, and since the luminescent spot made using the diffraction grating and the FG element cannot be easily influenced by the distance of an element and an object, it is preferred. Since most lights which there is no place shaded in the case of an FG element, and entered into the FG element can be used for generation of a luminescent spot, an energy efficiency target is expensive and preferred.

[0031]

It is realizable even if a small lens uses a ************ microlens array (MLA) that there is no crevice in all directions, as shown in the microlens array ** type lineblock diagram shown with the top view and A-A sectional view of drawing 6 (a). Also in this case, it is in every direction, and using the element from which a lens pitch is different, it is in every direction and can be different in the lattice spacing of a luminescent spot. Since such MLA can be easily manufactured by press working of sheet metal by a metallic mold, using a synthetic resin as a material, it is preferred. If MLA without a crevice is used between each lens like a graphic display, most light flux which has entered can be used for generation of a luminescent spot, and energy efficiency is highly preferred.

[0032]

As shown in the micro cylindrical lens array ** type lineblock diagram shown with the top view and

B-B sectional view of drawing 6 (b), a small silyne DORIKA lens may pile up two micro cylindrical lens arrays located in a line without the crevice with composition similar to an FG element. At this time, it is good between the arrays of two sheets to make it intersect perpendicularly mostly in directions with refracting power. That is, it arranges so that each diffraction direction may intersect perpendicularly mostly. That from which a lens pitch is mutually different is used as an array of two sheets piled up also in this case, it is in every direction and the lattice spacing of a luminescent spot is made different.

[0033]

The three-dimensional form measuring apparatus which is the embodiment of the invention described above can detect the abnormality, without spoiling privacy, when some abnormalities arise with ****, for example to the toilet of a care-for-the-old institution, etc. in a toilet.

[0034]

It is good also considering the using wavelength of a light source as wavelength other than visible light. When are constituted in this way and an image pick-up subject is a person, it can picturize without being noticed by the target person.

[0035]

As an example of an image sensor, the element of CMOS structure other than CCD may be used. There are some which were especially provided with the function of inter-frame difference ** or binarization into these at the element itself, and use of these elements is preferred.

[0036]

[Effect of the Invention]

As explained above, according to this invention, size from the interval a in the 2nd direction right-angled in the interval a fixed in the 1st direction, and the 1st direction The projection means which projects two or more becoming luminescent spots which were arranged in the shape of a lattice at intervals of [fixed] b, Have an imaging means which picturizes two or more luminescent spots projected on the imaging region on which the image pick-up subject 1 which saw from the projection means and was installed in the predetermined direction was put, and the angle of a predetermined direction and the 1st direction to make, When making n into a natural number, it is almost equal to arctan (b/(a-n)), and since said angle comprises arcsin (c/a) so that it may be size when setting the diameter of a luminescent spot to c, it becomes possible to provide the three-dimensional form measuring apparatus to which the time base range of the image pick-up subject was expanded.

[Brief Description of the Drawings]

[Drawing 1]It is a notional perspective view of the three-dimensional form measuring apparatus which is an embodiment of the invention.

[Drawing 2]It is a notional perspective view explaining the FG element used by the embodiment of drawing 1.

[Drawing 3]It is a top view showing the angle of a luminescent spot group and a ground line to make.

[Drawing 4]It is a top view which extracts and illustrates theta 3 of drawing 3.

[Drawing 5]It is a figure showing the table of the distance between the luminescent spot interval in the example of this invention, and two luminescent spots.

[Drawing 6]It is a mimetic diagram showing a microlens array and a micro cylindrical lens array among the diffraction gratings which can be used by an embodiment of the invention.

[Drawing 7]It is a top view showing a luminescent spot picture in case there is no object, and a picture with the luminescent spot moved to the next luminescent spot with an object.

[Description of Notations]

1 Image pick-up subject

2 Imaging region

10 Three-dimensional form measuring apparatus

11 Imaging optical system

11a Imaging lens
12 Projection optical system
13 FG element
15 Image formation face
14 Image processing device

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Field of the Invention]
Especially this invention relates to the three-dimensional form measuring apparatus for supervising the object in an object domain, a person's height, and change of a posture about a three-dimensional form measuring apparatus.
[0002]

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art]
As a monitoring instrument for getting to know abnormalities, without spoiling privacies, such as a patient in the sickroom of a hospital, or a toilet, The luminescent spot arranged in the shape of a lattice is projected on a surveillance object field, the picture is photoed, the position change from the reference position of the luminescent spot in the photoed picture detects height change of an object domain from the former, and the device which supervises the object in an object domain, a person's existence, and height change and a posture change is proposed.
[0003]

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention]
As explained above, in this invention, size from the interval a in the 2nd direction right-angled in the interval a fixed in the 1st direction, and the 1st direction The projection means which projects two or more becoming luminescent spots which were arranged in the shape of a lattice at intervals of [fixed] b, Have an imaging means which picturizes two or more luminescent spots projected on the imaging region on which the image pick-up subject 1 which saw from the projection means and was installed in the predetermined direction was put, and the angle of a predetermined direction and the 1st direction to make, When making n into a natural number, it is almost equal to arctan (b/(a-n)), and when setting the diameter of a luminescent spot to c, said angle comprises arcsin (c/a) so that it may be size.
Therefore, it becomes possible to provide the three-dimensional form measuring apparatus to which the time base range of the image pick-up subject was expanded.

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]
In such a conventional device, objective height is calculated by investigating the movement magnitude of a luminescent spot in case the object from the position of the luminescent spot in the state where an object etc. are not existed in a surveillance object field exists. However, distinction of luminescent spots became difficult in the place where a luminescent spot in case an object exists moves to the position of the luminescent spot of a next door in case an object does not exist, and measurement beyond it of the height was not completed. Signs that the luminescent spot of a certain place moves the situation of a luminescent spot picture in case an object does not exist to a surveillance object field to drawing 7 (b) to the next luminescent spot by existence of an object again are shown in drawing 7 (a). In drawing 7 (b), the luminescent spots 111c and 111d moved, it has moved to the position in drawing 7 (a) of the next luminescent spots 111a and 111b, and the object of the height which produces movement of the luminescent spot beyond this cannot be measured. If 111c and 111d in drawing 7 (b) move to the left further, it will become impossible for example, for the luminescent spot to distinguish from 111a and 111b.
[0004]
Then, this invention aims to let the height time base range of a supervisory object provide the large three-dimensional form measuring apparatus using a luminescent spot.
[0005]

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem]
To achieve the above objects, the three-dimensional form measuring apparatus 10 by invention concerning claim 1, For example, the interval a fixed to the imaging region 2 which places the image pick-up subject 1 in the 1st direction (y' shaft orientations (drawing 2)) as shown in drawing 1. . Saw from the projection means 12 which projects two or more luminescent spots 13a in which size becomes in the 2nd right-angled direction (x' shaft orientations) from the interval a, and which were arranged in the shape of a lattice at intervals of [fixed] b in the 1st direction (y' shaft orientations), and the; projection means 12, and were installed in the predetermined direction (y shaft orientations). Luminescent spot picture 1a' picturized by the imaging means 11 which picturizes two or more luminescent spots 13a projected on the imaging region 2 on which the image pick-up subject 1 was put, and the; imaging means 11, Compare reference image 2a', have the shape calculating means 14 which calculates three-dimensional shape of the image pick-up subject 1, and the angle theta of the direction of; predetermined (y shaft orientations), and said 1st direction (y' shaft orientations) to make. When making n into a natural number, it is almost equal to arctan (b/(a-n)), and when setting a diameter of a luminescent spot to c, said angle comprises arcsin (c/a) so that it may be size.
[0006]
A reference image is a picture which picturized typically a luminescent spot projected on an imaging region on which an image pick-up subject is not put. It may be based on coordinates which pinpoint a position of a luminescent spot picture, a reference image, and not only a ** image picture but a luminescent spot here.
[0007]
When constituted in this way, size from the interval a in the 2nd direction right-angled in the interval a fixed in the 1st direction (y' shaft orientations (drawing 2)), and the 1st direction A projection means which projects two or more becoming luminescent spots which were arranged in the shape of a lattice at intervals of [fixed] b, It has an imaging means which picturizes two or more luminescent spots projected on the imaging region 2 on which the image pick-up subject 1 which saw from a projection means and was installed in the predetermined direction was put. An angle of a predetermined direction and the 1st direction to make, When making n into a natural number, it is almost equal to arctan (b/(a-n)), and since said angle comprises arcsin (c/a) so that it may be size when setting a diameter of a luminescent spot to c, a time base range of an image pick-up subject is further expandable.
[0008]
As shown in drawing 2, still like a statement to claim 2 in the three-dimensional form measuring apparatus 10 according to claim 1. The projection means 12 is provided with the diffraction grating 13 of two sheets which passes the coherent light L1 generated with the light source L which generates the coherent light L1, and the; light source L, and the;2 sheet diffraction grating 13 is

arranged so that each diffraction direction may intersect perpendicularly mostly.
[0009]
The diffraction grating 13 is good for claim 3 like a statement to consider it as a fiber grating. Coherent light which passed a diffraction grating generates a pattern by interference. A diffraction grating may be a slit plate and a cylindrical lens array which cut everything but a fiber grating, for example, two or more slits, in parallel. A microlens array may be used instead of a cylindrical lens array of two sheets.
[0010]
[Embodiment of the Invention]
Hereafter, an embodiment of the invention is described with reference to drawings. Identical codes or similar numerals are given to the member which is mutually the same or corresponds in each figure, and the duplicate explanation is omitted.
[0011]
Drawing 1 is a notional perspective view showing the overview of the three-dimensional form measuring apparatus 10 which is an embodiment of the invention. The object 1 which carried out rectangular parallelepiped shape as the measuring object in a figure or an image pick-up subject is laid on the flat surface 2 as a measuring object area or an image pick-up object domain. The rectangular coordinate system XYZ is taken and the object 1 is put on the 1st quadrant of an XY coordinate system so that XY axis may be placed in the flat surface 2. It is good also considering a person as an image pick-up subject instead of an object.
[0012]
On the other hand, above the flat surface 2, the imaging optical system 11 as an imaging means is arranged on the Z-axis in a figure. Here, the imaging optical system is illustrated for convenience as what comprises the one convex lens 11a as an imaging lens. The imaging lens 11a of the imaging optical system 11 is arranged so that the optic axis may be in agreement with the Z-axis. The image formation face (image plain) 15 where the imaging lens 11a carries out image formation of the image of the flat surface 2 or the object 1 is a field which intersects perpendicularly with the Z-axis. xy rectangular coordinate system is taken in the image formation face 15, and the Z-axis passes along the starting point of xy coordinate system.
[0013]
At the imaging lens 11a and the equal distance, the fiber grating (FG) element 13 is arranged from the flat surface 2 at the place which only the distance d separated from the imaging lens 11a to the negative direction of the Y-axis. The luminescent spot projection optical system 12 as a projection means is constituted including FG element 13. The line which connects the center of the image formation face 15 and the center of an FG element here is called a ground line. The ground line has turned to y shaft orientations, and d is the distance (base length) of a base line direction. The laser beam L1 which the light source L generates in FG element 13 enters into Z shaft orientations, and the pattern 13a in which the point was arranged in the shape of a lattice is irradiated by the flat surface 2 so that it may explain with reference to drawing 2 later. That is, the object 1 and the flat surface 2 are illuminated by the pattern state illumination light. The computer 14 as an image processing means is electrically connected to the imaging optical system 11. The internal organs of the shape calculating means are carried out into the computer 14. That is, it is an operation program for example, it was installed in storage parts stores, such as a hard disk and RAM.
[0014]
Furthermore with reference to drawing 1, the principle of three-dimensional shape measuring is explained. The portion in which the object 1 exists is interrupted by the object 1, and the luminescent spot pattern 13a projected on the flat surface 2 by FG element 13 explained in detail later does not arrive at the flat surface 2. If the object 1 does not exist here, the luminescent spot on which it should be projected by the point 2a (X, Y, Z) on the flat surface 2 is projected by the point 1a (X1, Y1, Z1) on the object 1. the luminescent spot moved to the point 1a from the point 2a

-- on the image formation face 15, the place which should be carried out image formation carries out image formation to point 2a' (x, y) at point 1a' (x, y+delta) from the place from which the imaging lens 11a and FG element 13 have separated only the distance d. That is, only the distance delta moves to y shaft orientations. In practice, if point 1a' is not a point on the y-axis, only deltax will move also to x shaft orientations, but the display is omitted here.

[0015]

By measuring this delta, the position of the point 1a on the object 1 can specify in three dimensions. Thus, if a certain luminescent spot does not exist [the object 1], when measuring the difference of the point which should be carried out image formation on the image formation face 15, and the actual image formation position on the image formation face 15, the three-dimensional shape of the object 1 is measurable. Or it is good although the three dimensional coordinates of the object 1 are measurable. If the pitch of the pattern 13a, i.e., the pitch of a luminescent spot, is made fine to such an extent that the correspondence relation of a luminescent spot does not become unknown, the three-dimensional shape of the object 1 can be measured so in detail.

[0016]

The center of FG element 13, and the center of the imaging lens 11a, Detach only the distance d in parallel with the flat surface 2, and it is arranged, and the distance to the image formation face 15 from the imaging lens 11a I (El) (almost equal to the focus of the convex lens 11a as an imaging lens), The height from the flat surface 2 of the point 1a of h and the image pick-up subject 1 of the distance from the imaging lens 11a to the flat surface 2 is Z (in drawing 1, it illustrates with Z1). an image pick-up -- a subject -- one -- a flat surface -- two -- a top -- placing -- having had -- a result -- an image formation face -- 15 -- a top -- a point -- two -- a -- ' -- delta -- only -- having separated -- a point -- one -- a -- ' -- having moved .

Z is expressed with the formula which contains delta like the following formula 1 in such a relation. If this formula is used, the posture of the person in a toilet, etc. can be known in three dimensions.

$Z = (h^2\text{anddelta}) / (d\text{-}l\text{+}h\text{-delta})$ -- Formula 1

[0017]

FG element 13 is explained with reference to drawing 2. A diameter arranges in a sheet shaped about 100 optical fibers which are tens of microns and about 10 mm in length, and FG element 13 piles it up so that a two-sheet fiber may intersect perpendicularly. An FG element is arranged in parallel [a sheet] (it is right-angled to the Z-axis) with the flat surface 2. The laser beam L1 which laser light source L generated in this FG element 13 is entered in Z shaft orientations. Then, the laser beam L1 serves as a spherical wave, after it condenses with the focus of each optical fiber, spreads, and goes and interferes, and the luminescent spot pattern 13a which is a luminescent spot matrix at the shape of a tetragonal lattice is projected on the flat surface 2 which is a surface of projection as a measurement region or an imaging region. In other words, so to speak, the flat surface 2 or the object 1 on it is illuminated by the luminescent spot pattern state illumination light by projecting the luminescent spot pattern 13a.

[0018]

According to such FG element 13, the good sharp illumination pattern of the contrast of punctiform light (luminescent spot) can be obtained according to the diffraction effect of light, without depending on the distance from a grating, and it is suitable for the image pick-up of a pattern. Since three-dimensional shape can be measured only by measuring and calculating the movement magnitude of a luminescent spot when using such an FG element, it is realizable by the calculating means in which measurement of three-dimensional shape is comparatively easy. Since light volume can be concentrated, the image pick-up of an illumination pattern (here luminescent spot) can be simply performed also in the state where the circumference is bright, and it is suitable.

[0019]

The optical fiber of FG element 13 has not always turned to the base line direction (y shaft orientations in a figure), sets the axis of rotation as an axis parallel to Z shaft orientations which

pass along the center of FG element 13 in parallel with a xy plane, and has rotated only theta. If coordinates parallel to the optical fiber which intersects perpendicularly among a figure are made into x'y' coordinates, as for y' axis, only the angle theta leans to the x axis to the y-axis, as for x' axis. That is, the angle of one lattice direction and ground line to accomplish is theta.

[0020]

The interval of a direction parallel to a and x' axis is set to b for the interval of a direction parallel to y' axis of the lattice-like luminescent spot pattern on the flat surface 2 here. the diameter of the optical fiber which intersects perpendicularly -- both persons -- although it is almost equal -- the diameter of the optical fiber of y' shaft orientations -- x' -- if it is made thicker than the diameter of the optical fiber of shaft orientations, the interval of the luminescent spots of a luminescent spot pattern will serve as a relation of a<b. The luminescent spot pattern of drawing 1 shows the case of theta= 0.

[0021]

Drawing 3 is a luminescent spot picture at the time of using the FG element that a luminescent spot interval is set to a and b (a<b). Such a luminescent spot picture is realizable by using the element that it differs from each other as explained with reference to drawing 2, the diameter of a fiber, i.e., the fiber pitch, of the length of an FG element, and width. Since it is considered the equation of the interference fringe by interference by a multiplex slit as shown in the following equation 2 the same way, the formula of the position of the luminescent spot by laser and an FG element can change the interval of an interference fringe, if slit spacing p, i.e., a fiber pitch, is changed. Here, as for y_m, h considers it as the distance from an FG element to an illuminated face (flat surface of an imaging region) by a natural number and lambda considering it as the wavelength of light, and p makes slit spacing y axial position and m which give the periodic sharp maximum.

y_m= m-lambda-h/p -- Formula 2

[0022]

the angle of the short (at drawing 3, an interval is a) lattice direction and ground line of the luminescent spot interval of a luminescent spot array to accomplish -- theta 0, theta 1, theta 2, and ... it can place like thetan. In drawing 3, it writes to theta 4 for explanation, and the graphic display is omitted more than theta5. Thus, by setting up the direction of a ground line, the interval of a certain luminescent spot and adjoining luminescent spot of the base line direction can be enlarged, and the height time base range of the object 1 can be extended. Disregard of the size of a luminescent spot will express the distance with an adjoining luminescent spot like a lower type.

In the case of theta 0 ..... a

In the case of theta 1 ..... $(a^2+b^2)^{1/2}$

In the case of theta 2 ..... (2anda) $(^2+b^2)^{1/2}$

In the case of theta 3 ..... (3anda) $(^2+b^2)^{1/2}$

In the case of theta 4 ..... (4anda) $(^2+b^2)^{1/2}$

[0023]

Thus, when a lattice is leaned to a ground line, as compared with the case where it does not lean, the distance between adjoining luminescent spots becomes large. Here, even when a luminescent spot is small enough, actually, n of thetan is restricted by the spot diameter of a luminescent spot, fluctuation, etc. rather than is infinite. If theta is expressed with a general formula here, it will become like a following formula. If theta is made almost equal to such a value, a large distance with an adjoining luminescent spot can be taken.

Theta=arctan (b/(a-n)) -- Formula 3

[0024]

Since enlarging a luminescent spot interval simultaneous in all directions [a luminescent spot array], being able to lessen reduction of the number of the luminescent spot per unit area, and

making an objective height measuring spot into a non-dense rather than the method of expanding a height time base range will decrease if it has such composition, three-dimensional measurement of a more exact object is attained. The base length d can expand a height time base range, without reducing the sensitivity of low height, since it does not change.

[0025]

When leaning a luminescent spot lattice direction to a ground line, extending the adjoining luminescent spot interval of a base line direction so that it may explain below with reference to drawing 4 if a<b and a luminescent spot position moves with an object, it becomes possible to avoid whether it strikes to luminescent spots other than an adjoining luminescent spot, and that it keeps.

[0026]

An embodiment of the invention is described with reference to drawing 4. There is a relation of a<b to a luminescent spot interval among a figure, and the angle of the direction of the interval a and a ground line is taken at theta=arctan (b/(3anda)). In such arrangement of a ground line and a luminescent spot lattice, in connection with objective height, move the luminescent spot 0 of the bottom corner of the left in the figure in the direction of the luminescent spot 1 of the position of four rows from the two-line left from figure Nakashita, but. In this middle, a possibility of the luminescent spot 2 (or luminescent spot 3 of the two-line left from figure Nakashita to three rows) of two rows of being immediately located in the side occurs from the one-line left from figure Nakashita. When a luminescent spot lattice spacing is defined as a and b as shown in a figure, the diameter of a luminescent spot is set to c and n is made into a natural number, the crevice s between the luminescent spots at the time of position **** with the luminescent spot 0 nearest to the luminescent spot 2 is expressed with a following formula.

$s=a-b/(a-n)\ ({}^2+b^2)^{1/2}-c$ -- Formula 4

[0027]

For example, when distance l_{01} (El) between the a=b= luminescent spots 0-1 which deducted the size of s and a luminescent spot when 5 mm and c= 1 mm becomes as it is shown in Table 1 of drawing 5 (a), and it carries out to n= 5 or more, it turns out that luminescent spots lap and distinction becomes difficult. What is necessary is to just be referred to as s> 0 in the formula 4, in order to avoid this. Namely, what is necessary is just to make it fill a following formula.

Theta>arcsin (c/a) -- Formula 5

[0028]

Here, if there is no influence of a noise etc. as shown in Table 2 of (b) when it changes into b= 8 mm (> a= 5 mm), it can be made shallow to the angle of n= 7. At this time, it turns out that the value of l_{01} is also large and the height time base range has expanded it. Thus, it is in every direction, and by using the luminescent spot picture of a different luminescent spot interval, the adjoining luminescent spot of a base line direction can be lengthened, and it becomes possible to expand a height time base range.

[0029]

in the above, drawing 3 explained -- as -- theta 1, theta 2, and theta 3 -- if .... and an angle are made shallow (however, it is not 0 times), the adjoining luminescent spot interval of a base line direction spreads, and a height time base range can be expanded, but this angle is not actually made not much shallowly under the influence of the size of a luminescent spot, etc. Then, the angle can be made shallow by using arrangement of a luminescent spot which was explained by drawing 4.

[0030]

Although the luminescent spot array from which a lattice spacing is different using FG (fiber grating) element from which the diameter of a fiber is different by length and its side was realized in the embodiment described so far, It is realizable also by piling up the general transmission type one-dimensional diffraction grating as other means so that two sheets and a lattice may intersect perpendicularly. In this case, using that from which the pitch of a diffraction grating is different, it is

in every direction and the lattice spacing of a luminescent spot is made different. There is little dotage, and since the luminescent spot made using the diffraction grating and the FG element cannot be easily influenced by the distance of an element and an object, it is preferred. Since most lights which there is no place shaded in the case of an FG element, and entered into the FG element can be used for generation of a luminescent spot, an energy efficiency target is expensive and preferred.

[0031]

It is realizable even if a small lens uses a ************ microlens array (MLA) that there is no crevice in all directions, as shown in the microlens array ** type lineblock diagram shown with the top view and A-A sectional view of drawing 6 (a). Also in this case, it is in every direction, and using the element from which a lens pitch is different, it is in every direction and can be different in the lattice spacing of a luminescent spot. Since such MLA can be easily manufactured by press working of sheet metal by a metallic mold, using a synthetic resin as a material, it is preferred. If MLA without a crevice is used between each lens like a graphic display, most light flux which has entered can be used for generation of a luminescent spot, and energy efficiency is highly preferred.

[0032]

As shown in the micro cylindrical lens array ** type lineblock diagram shown with the top view and B-B sectional view of drawing 6 (b), a small silyne DORIKA lens may pile up two micro cylindrical lens arrays located in a line without the crevice with composition similar to an FG element. At this time, it is good between the arrays of two sheets to make it intersect perpendicularly mostly in directions with refracting power. That is, it arranges so that each diffraction direction may intersect perpendicularly mostly. That from which a lens pitch is mutually different is used as an array of two sheets piled up also in this case, it is in every direction and the lattice spacing of a luminescent spot is made different.

[0033]

The three-dimensional form measuring apparatus which is the embodiment of the invention described above can detect the abnormality, without spoiling privacy, when some abnormalities arise with ****, for example to the toilet of a care-for-the-old institution, etc. in a toilet.

[0034]

It is good also considering the using wavelength of a light source as wavelength other than visible light. When are constituted in this way and an image pick-up subject is a person, it can picturize without being noticed by the target person.

[0035]

As an example of an image sensor, the element of CMOS structure other than CCD may be used. There are some which were especially provided with the function of inter-frame difference ** or binarization into these at the element itself, and use of these elements is preferred.

[0036]

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a notional perspective view of the three-dimensional form measuring apparatus which is an embodiment of the invention.
[Drawing 2]It is a notional perspective view explaining the FG element used by the embodiment of drawing 1.
[Drawing 3]It is a top view showing the angle of a luminescent spot group and a ground line to make.

[Drawing 4]It is a top view which extracts and illustrates theta 3 of drawing 3.
[Drawing 5]It is a figure showing the table of the distance between the luminescent spot interval in the example of this invention, and two luminescent spots.
[Drawing 6]It is a mimetic diagram showing a microlens array and a micro cylindrical lens array among the diffraction gratings which can be used by an embodiment of the invention.
[Drawing 7]It is a top view showing a luminescent spot picture in case there is no object, and a picture with the luminescent spot moved to the next luminescent spot with an object.
[Description of Notations]
1 Image pick-up subject
2 Imaging region
10 Three-dimensional form measuring apparatus
11 Imaging optical system
11a Imaging lens
12 Projection optical system
13 FG element
15 Image formation face
14 Image processing device

[Translation done.]

JAPANESE [JP,3689720,B]

[Translation done.]